HEAT EXCHANGER SYSTEM FOR COOLING OPTICAL FIBERS

Cross-Reference to Related Applications

This application claims priority from U.S. Provisional Patent Application Serial No. 60/460,121, entitled "Optical Fiber Heat Exchanger", and filed April 3, 2003. The disclosures of this provisional patent application is incorporated herein by reference in its entirety.

Background of Invention

Field of Invention

The present invention pertains to heat exchangers employing a coolant gas to cool fibers, in particular optical fibers, moving through the exchangers.

Related Art

Optical fibers are typically formed by a process in which hot fibers are drawn from the end of a massive cylindrical silica or glass perform that has been heated up to its softening point in a drawing furnace. This drawing process is followed by cooling the fibers within a coolant chamber or heat exchanger utilizing a coolant fluid that flows through the heat exchanger in a co-current or countercurrent direction with respect to the velocity vector of the fiber traveling through the exchanger. The drawn fibers must be cooled to a sufficient temperature within the heat exchanger prior to cladding the fiber with a heat sensitive protective coating.

Drawing speeds for optical fibers are presently on the order of about 20 meters per second and increasing. As the fiber drawing speeds increase, it becomes increasingly important to rapidly and effectively cool the hot drawn optical fibers while minimizing the height or length of the heat exchanger required to cool the fibers. Thus, it is desirable to provide a heat exchanger system that effectively controls the cooling rate of fibers flowing through the system.

Summary of the Invention

Accordingly, it is an object of the present invention to provide a heat exchanger system for a fiber that effectively cools the fiber at a selected rate.

It is another object of the present invention to provide a heat exchanger system that effectively controls the cooling rate of the fiber by controlling the temperature of the coolant fluid used to cool the fiber during system operation.

The aforesaid objects are achieved individually and/or in combination, and it is not intended that the present invention be construed as requiring two or more of the objects to be combined unless expressly required by the claims attached hereto.

In accordance with the present invention, a heat exchanger system for cooling a fiber includes an outer tube section, an inner tube section disposed within and separated a selected distance from the outer tube section to form an annular gap therebetween, and a plurality of fins extending transversely from internal peripheral wall portions of the inner tube section toward a central axis of the inner tube section. The inner tube section includes an internal passage configured to receive and cool the fiber as the fiber moves through the heat exchanger, and the fins facilitate heat transfer between a cooling medium flowing through the annular gap and a coolant fluid flowing within the inner tube section during system operation. The fins can be formed in any suitable configuration and with any one or more selected geometries. Optionally, the fins may include hollow portions to facilitate the flow of cooling medium through portions of the fins.

In one embodiment of the invention, the internal passage includes a plurality of active zones that direct the coolant fluid toward the fiber to facilitate cooling of the fiber within the active zones and a plurality of passive zones that direct the coolant fluid away from the fiber to facilitate heat transfer between the cooling medium and the coolant fluid in the passive zones. In this embodiment, the heat exchanger includes a plurality of fins extending transversely from at least one internal wall and toward an axial center of the heat exchanger, where fins are

spaced from each other along an axial dimension of the heat exchanger and the active and passive zones are at least partially defined along a portion of the fins. Optionally, cooling enclosures can be disposed within spaces defined between adjacent fins so as to define a series of sub-chambers between the enclosures and their adjacent fins. The fins and cooling enclosures are hollow and are further configured to receive a cooling medium to facilitate heat transfer between the cooling medium and the coolant fluid within at least the passive zones during travel of the coolant fluid within the heat exchanger.

In another embodiment, the fins are formed by a spiraling element extending in an axial dimension along an internal periphery of the inner tube section.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of specific embodiments thereof, particularly when taken in conjunction with the accompanying drawings wherein like reference numerals in the figures are utilized to designate like components.

Brief Description of the Drawings

Fig. 1 is a schematic cross-sectional view of a desired flow path of coolant fluid through a heat exchanger in accordance with an embodiment of the present invention.

Fig. 2 is a schematic view in partial section of one embodiment of a heat exchanger system in accordance with the present invention.

Fig. 3 is a cross-sectional view in perspective of the heat exchanger of the system of Fig. 1.

Fig. 4 is a further sectional view in perspective of the heat exchanger of Fig. 3.

Fig. 5 is a cross-sectional view of another embodiment of a heat exchanger for use in a system in accordance with the present invention.

Description of Preferred Embodiments

The heat exchanger system of the present invention utilizes a heat exchanger configured to receive a continuously moving fiber (e.g., an optical fiber formed from silica or glass) at a fiber inlet, one or more inlets and outlets to receive coolant fluid that contacts and cools the fiber within the heat exchanger and, optionally, one or more mechanical devices (e.g., pumps, fans, etc.) to recycle or circulate the coolant fluid through the heat exchanger. In addition, the coolant system may also include one or more controllers, flow meters, valves, etc. within the recycle lines to selectively control the flow rate of recycled coolant fluid to the heat exchanger. Further, the heat exchanger of the coolant system may include gas seals disposed at one or more suitable locations to minimize or prevent the escape of coolant fluid from the heat exchanger during system operation. Examples of suitable sealing arrangements that may be employed in the heat exchanger of the present invention are described in co-pending U.S. Patent Application Serial No. 10/765,468, the disclosure of which is incorporated herein by reference in its entirety.

Coolant fluid is delivered from a coolant supply source into the heat exchanger at a selected flow rate. The coolant fluid may be any one or combination of suitable cooling gases and/or cooling liquids. Exemplary cooling gases suitable for use include, without limitation, helium, neon, argon, krypton, xenon, hydrogen, nitrogen, and carbon dioxide. Helium is a preferred coolant fluid for cooling optical fibers. However, certain combinations of coolant gases, such as a combination of substantially pure helium and substantially pure hydrogen, or a combination of one or more gases with one or more liquids or a combination of two or more liquids, may be utilized in certain situations. Selected combinations of coolant fluids are useful in that they can provide a certain "fine tuning" or more precise control of the cooling rate of the fiber in the heat exchanger due to the modification in the overall heat transfer coefficient that occurs by combination of different gas mixtures and/or gas purity levels. Optionally, a coolant gas or a combination of coolant gas mixtures can include one or more gas dopants that are capable of modifying the structural and/or chemical properties of the surface

of the fiber in a desirable and beneficial manner when the coolant gas contacts the fiber within the exchanger. Exemplary dopants include, without limitation, silanes, phosphines, fluorine, chlorine, gaseous organometallic compounds, and combinations thereof.

The heat exchanger system of the present invention provides effective cooling of fibers at a desired cooling rate during system operation and facilitates a reduction in the size of the heat exchanger through which the fiber travels while increasing the cooling rate within the heat exchanger. This is accomplished by providing an inner tube section within an outer tube section, where an annular gap separates the two sections and a cooling fluid medium is provided within the annular gap. Cooling fins extend within an internal passage of the inner tube section to facilitate control of the cooling rate of the fiber traveling through the internal passage as it is being cooled by a coolant fluid also traveling through the internal passage system operation. The arrangement and configuration of the cooling fins can be selected to control the flow path of the coolant fluid through the internal passage, as described below, so as to ensure the coolant fluid is within a selected temperature range and the fiber is cooled at a desired rate during system operation. The term “cooling fins” or “fins”, as used herein, refers to a vane, rib or other suitable extension member that extends transversely from internal wall portions of the inner tube section and facilitates heat transfer along the extension member. Preferably, the cooling fins extend a selected distance toward the central axis of the inner tube section to facilitate heat transfer from the outer surface portions of the inner tube section a sufficient distance within the inner tube section.

In one embodiment of the present invention, the coolant fluid flowing through the internal passage of the heat exchanger is controlled such that the coolant fluid travels between active regions or zones, where the coolant fluid is directed toward and/or engages and cools the fiber, to passive regions or zones, where the coolant fluid is directed away from the fiber and is cooled by the internal fin and/or other surfaces of the inner tube section of the heat exchanger. An exemplary flowpath for the coolant fluid through the heat exchanger is illustrated

in the schematic of Fig. 1. In particular, Fig. 1 generally depicts a hot optical fiber 4 traveling in a substantially linear manner through a heat exchanger 2, while coolant fluid 6 travels in a winding or undulating path through the exchanger between passive zones 8, where the coolant fluid 6 is directed away from the fiber 4 and toward one or more internal cooling walls 12 of the heat exchanger to effect heat transfer between the internal cooling walls and the coolant fluid, and active zones 10, where the coolant fluid 6 is directed toward the fiber 4 to effect cooling of the fiber. This undulating flow path can be achieved by natural convection and/or forced flow (e.g., via one or more mechanical devices such as pumps, fans, etc.) as the coolant fluid travels the axial dimension of the inner tube section.

The undulating flow path for coolant fluid within the heat exchanger is achieved, at least in part, by providing cooling fins that extend transversely from the internal wall surfaces of the heat exchanger toward the central axis of the exchanger so as to define sub-chambers between the fins where heat transfer between the cooling medium and the coolant fluid can occur. An exemplary heat exchanger using cooling fins to achieve active and passive zones and establish the flow of coolant fluid through the heat exchanger in an undulating manner as described above is depicted in Figs. 2-4. Heat exchanger 20 is formed of any one or more suitable metal materials (e.g., copper, aluminum, stainless steel, etc.) and includes a generally cylindrical outer tube section 22 and a generally cylindrical and hollow inner tube section 24 disposed within and separated from the outer tube section 22 so as to form a sealed annular gap 23 between the two sections. It is noted, however, that the outer and inner tube sections may include any other suitable geometric configurations (e.g., rectangular, multi-faceted, etc.). A fiber inlet 40 and outlet 42 are disposed at opposing longitudinal ends of the exchanger 20 and are configured to receive and permit a moving fiber 44 to travel through the heat exchanger for processing as described below.

Cooling fins are formed and extend along and inward toward the central axis of the inner tube section to provide a winding or undulating flow path for coolant fluid flowing within and along the axial dimension of the inner tube section as

generally described above and depicted in Fig. 1. Preferably, the fins are formed of a suitable material (e.g., copper or aluminum) that facilitates sufficient heat transfer between cooling medium flowing within the annular gap between the internal and outer tube sections and coolant fluid flowing within the inner tube section during system operation. The fins may be formed in any suitable manner along the inner tube section of the heat exchanger in order to achieve this desired flow for coolant fluid. For example, the fins may be constructed of separate elements extending transversely along and toward the central axis of the inner tube section. Alternatively, each pair of fins may be constructed of a single element, with a cut-out section to form the gap between pairs of fin elements so as to form the fiber channel. Further still, the fins may be constructed as a single "forged fin" element that spirals axially along the peripheral surfaces of the inner tube section (i.e., in a helical manner, similar to the configuration depicted in the embodiment of Fig. 5), with the fiber channel being defined between the terminal edges of the spiral element. The fins may also be arranged in a double helix configuration around the inner tube section periphery. The fins can be parallel or non-parallel with each other depending upon the desired flow path characteristic for coolant fluid in a particular application.

Referring to the embodiment of Figs. 2-4, a series of fins 26 extend transversely within the inner tube section toward the central axis of the heat exchanger 20. The fins 26 are separated a selected distance from each other along the axial dimension of the exchanger 20 and are arranged in pairs. Each fin in a pair is aligned with and extends toward the other fin in the pair so as to form a gap within the inner tube section and between each pair of fins. A generally linear channel 25 is at least partially defined by the combination of gaps disposed between pairs of fins, and this channel 25 extends axially between and communicates with the fiber inlet 40 and the fiber outlet 42 to allow the optical fiber to travel through the exchanger 20 during system operation. The active zones within the heat exchanger 20 are defined at least in part at the gaps between fins 26 which together form the fiber channel 25. The fins 26 are at least partially hollow and are sealed at the ends extending within the inner tube

section 24 but are open to the annular gap 23 defined between the outer tube section 22 and the inner tube section 24 to permit cooling medium flowing within the annular gap to enter the fins 26 during system operation as described below. Alternatively, and depending upon a particular application, the fins may be solid and still provide effective cooling of both the coolant fluid and the fiber traveling through the heat exchanger during system operation.

Optionally, cooling enclosures are placed between adjacent fins to further define generally curved or U-shaped sub-chambers that enhance the undulating flow path for coolant fluid within the heat exchanger. The cooling enclosures can be formed in any suitable manner within the inner tube section in order to define such curved sub-chambers. For example, the cooling enclosures may be formed as a single, spiraling or helical element as described above for the fins, where the cooling enclosure element winds or is "threaded" between a corresponding helical fin element. Alternatively, the cooling enclosures may be formed as a plurality of separate elements. The separate elements may include pairs of aligned elements disposed along opposing longitudinal cross sections of the inner tube section and/or single elements extending across both longitudinal cross sectional portions of the inner tube section and with a cut-out portion that defines the fiber channel.

Referring to the embodiment of Figs. 2-4, cooling enclosures 28 extend transversely within the inner tube section 24 in a direction (as viewed from the cross-sectional depiction in Fig. 2) that is generally perpendicular to the direction in which the fins 26 extend within the inner tube section. Each cooling enclosure 28 is hollow and extends between opposing peripheral wall portions of the inner tube section 24 so as to be in fluid communication with the annular gap 23 while otherwise being sealed along all other side wall surfaces.

Each cooling enclosure 28 is further disposed between two adjacent fins 26 on each longitudinal cross-sectional portion of the inner tube section 24 of the heat exchanger 20. A cut-out section in each cooling enclosure 28 forms a gap which further defines a portion of the fiber channel 25, and each enclosure 28 is also

spaced a suitable distance from each adjacent fin 26 to form a curved space or sub-chamber 30 between the internal walls forming the enclosure and adjacent fins. This sub-chamber 30 at least partially defines a passive zone through which the coolant fluid flows as described below.

A sufficient amount of cooling medium 32 is provided within the annular gap 23 to fill the fins 26 and cooling enclosures 28 in order to effectively maintain the coolant fluid within a selected temperature range during system operation. The cooling medium can be water, liquid or gaseous cryogenic fluids (e.g., nitrogen, helium, argon, hydrogen, oxygen, etc.), or any other single or combination of suitable fluid mediums capable of cooling the coolant fluid at a selected rate and to a selected temperature when the coolant fluid travels through the passive zones of the heat exchanger. Alternatively, the fluid medium may be heated to a selected temperature to prevent rapid cooling of the fiber in the heat exchanger. Basically, any one or more combinations of fluids (e.g., heated or cooled water, liquid or gaseous cryogenics, liquid or gaseous hydrocarbons or hydrocarbon mixtures, heated oils, etc.) may be provided at any desired temperatures within the outer tube section to achieve precise control of the temperature of the coolant fluid and thus the cooling rate of the fiber traveling through the heat exchanger.

An inlet conduit 34 and an outlet conduit 36 extend transversely from the outer tube section 22 at axially spaced locations from each other and near the ends of the outer tube section to facilitate the flow of cooling medium into and through the annular gap 23 and cooling enclosures 28 when the conduits are connected to a fluid medium supply source (not shown). The cooling medium may be continuously flowing through the annular gap 23 and cooling enclosures 28 or, alternatively, initially filled and then maintained within these sections during system operation. The cooling medium may also be purified (e.g., utilizing any suitable filtration and/or separation devices) and recycled for reuse during system operation and/or during periods in which the system is not being used. Further, the cooling medium can be directed through a secondary heat exchanger prior to re-entry into the heat exchanger 20 so as to ensure the cooling medium is at an appropriate temperature within the heat exchanger 20.

The heat exchanger also includes at least one coolant fluid inlet and at least one coolant fluid outlet extending transversely from the outer tube section at axially separated locations to permit the flow of coolant fluid into and out of the heat exchanger. In the embodiment depicted in Fig. 2, an inlet conduit 46 is provided at a generally central location along the axial dimension of the heat exchanger to facilitate delivery of coolant fluid centrally into passage 25 to engage with the fiber 44. A first outlet conduit 48 is provided near the top portion of the exchanger 20 to receive coolant fluid flowing up from the inlet conduit 46 and through passage 25, and a second outlet conduit 50 is provided at the bottom portion of the exchanger 20 to receive coolant fluid flowing down from the inlet conduit 46 and through passage 25. Thus, coolant fluid in the heat exchanger of Fig. 2 flows from a central location within the heat exchanger outward toward the top and bottom of the exchanger. However, it is noted that the coolant fluid flow in the heat exchanger may be configured in any other suitable manner depending upon a particular application (e.g., top to bottom, bottom to top, etc.).

The coolant fluid emerging from the outlet conduits 48 and 50 can be discarded or, alternatively, purified and/or recycled. In the embodiment of Fig. 2, the first and second outlet conduits 48 and 50 are connected with the inlet conduit 46 via suitable recycle lines (e.g., including piping, associated fittings and valves, etc.) to permit recycling of the coolant fluid during system operation. The flow of coolant fluid through the heat exchanger can be achieved by natural and/or forced convection. As depicted in Fig. 2, recycle pumps 52 and 54 are disposed in the recycle line to facilitate recycling of the coolant fluid. In particular, the pumps 52 and 54 establish a pressure differential between the inlet conduit 46 and each outlet conduit 48 and 50 to facilitate the flow of fluid in the two general directions within the heat exchanger 20 as illustrated by the arrows in Fig. 2. Alternatively, the recycle of coolant fluid may be achieved by a fan driven mechanism and/or any other suitable mechanically driven process.

Optionally, any suitable number of valves, flow meters, fluid analyzers, purification devices and/or branched or other fluid supply lines may be integrated

into the recycle lines as needed to facilitate the delivery of fresh coolant medium and/or coolant medium at any desired composition and flow rate to the inlet conduit 46.

During system operation, a hot drawn optical fiber 44 is directed to the inlet 40 of the heat exchanger 20 and into fiber passage 25, where the fiber continuously moves through the passage 25 to the fiber outlet 42. Coolant fluid is directed into the heat exchanger 20 via the inlet conduit 46, where it initially engages the optical fiber. Cooling medium 32 is continuously flowed into and maintained at a suitable temperature within the fins 28 and cooling enclosures 28, via inlet and outlet conduits 34 and 36, so as to selectively control the temperature of the coolant fluid as it travels from the active zones to the passive zones within the exchanger as described below.

The coolant fluid is drawn through the heat exchanger by natural convection and/or forced flow (e.g., via pumps 52 and 54). In particular, the coolant fluid engages and cools the fiber 44 in the active zones, which are at least partially defined at the gaps between pairs of fins 26. As the coolant fluid moves around the ends of the fins 26, the coolant fluid is then drawn into the passive zones, which are at least partially defined by the curved sub-chambers 30 located between the walls of adjacent fins 26 and cooling enclosures 28 disposed between the adjacent fins. The coolant fluid is drawn from the active zones into the passive zones by natural convection and/or forced flow. Thus, the coolant fluid alternates between active zones (where it cools the fiber) and passive zones (where the heat transfer occurs between the cooling medium and the coolant fluid), resulting in an undulating motion of the coolant fluid in directions toward and away from the fiber (as generally indicated by the arrows shown in Fig. 2) as it travels axially within the heat exchanger toward outlet conduits 48 and 50. Pumps 52 and 54 are operated as necessary to create a pressure differential between the inlet conduit 46 and the outlet conduits 48 and 50 in order to drive the coolant fluid in the undulating motion through the heat exchanger at one or more desired flow rates.

The heat exchange between the cooling medium and the coolant fluid and the cooling rate of the fiber within the heat exchanger can be adjusted by controlling the thickness dimensions of the cooling enclosures 28 (as indicated by the dimension “a” in Fig. 2) and the thickness dimensions of the fins 26 (as indicated by the dimension “b” in Fig. 2). Controlling the ratio of a/b affects the dimensions of both the active and passive zones, which in turn controls the cooling rate for the fiber moving through the exchanger. For example, the ratio of thickness of cooling enclosures to fins may varied from values in which a/b approaches zero to where a/b approaches 100. Preferred ranges of a/b ratios are from about 2 to about 5.

Other heat exchanger embodiments are also encompassed by the present invention with different fin arrangements that provide effective cooling of both the coolant fluid and the fiber traveling through the heat exchanger. For example, heat exchangers may include fin arrangements without the cooling enclosures as described above and depicted in Figs. 2-4.

An example of another heat exchanger embodiment is illustrated in Fig. 5. Heat exchanger 100 includes a generally cylindrical outer tube section 122 and a generally cylindrical and hollow inner tube section 124 disposed within and separated from the outer tube section 122 so as to form a sealed annular gap 123 between the two sections. It is noted, however, that the outer and inner tube sections may include any other suitable geometric configurations (e.g., rectangular, multi-faceted, etc.). The internal and outer tube sections may be constructed of any suitable materials (e.g., stainless, steel, copper and/or aluminum). A fiber inlet 140 and outlet 142 are disposed at opposing longitudinal ends of the exchanger 100 and are configured to receive and permit a moving fiber (not shown) to travel through the heat exchanger during system operation.

The outer tube section 122 includes an inlet conduit 134 and an outlet conduit 136 extending transversely from the outer tube section and respectively disposed near the lower and upper ends of the heat exchanger 100 to facilitate the flow of cooling medium through the annular gap 123. Similarly, the inner tube section

124 includes an inlet conduit 146 and an outlet conduit 148 extending transversely from the internal and outer tube sections and respectively disposed near the lower and upper ends of the heat exchanger to facilitate the flow of coolant fluid through the inner tube section in a counter-current manner with respect to the movement of the fiber through the inner tube section during system operation. The coolant fluid and cooling medium may be of any suitable one or combination of fluids as described above. For example, the coolant fluid can be helium, while the cooling medium can be water.

Cooling fins are formed and extend along and inward toward the central axis of the inner tube section. The cooling fins can be formed along the internal wall surfaces of the inner tube section in any suitable manner and can include any selected geometric configurations. For example, the cooling fins may be formed as separate elements extending at any number of selected locations both axially and radially along the inner wall perimeter of the inner tube section. Alternatively, the cooling fins may be formed as axially spaced elements, where each element includes a cut-out portion that defines a generally linear channel for the fiber. Further still, the cooling fins may be formed from one or more single spiraling or helical elements disposed on the inner wall perimeter of the inner tube section.

Referring to the embodiment of Fig. 5, the cooling fins 126 of the heat exchanger 100 are formed of a single helical or spiraling formed fin element that extends along the inner periphery of the inner tube section from its lower end to its upper end. The fins are solid (i.e., not hollow) and are constructed of a suitable material (e.g., copper or aluminum) to facilitate effective heat transfer between cooling medium disposed within the annular gap 123 and coolant fluid flowing within the inner tube section 124 during system operation. Alternatively, the fins can be hollow to permit cooling medium to extend within the fins in a similar manner as described above for the fins of Figs. 2-4. The fins extend transversely a selected distance from and toward a central axis of the inner tube section 124 so as to define a generally linear fiber channel within the inner tube section.

Each 180 - 360° rotational segment of the fin spiral along the inner tube section wall can be of the same or varying thickness, thus facilitating similar or different rates of heat transfer between the cooling medium and the coolant fluid along the axial dimension of the heat exchanger. Further, the distance between each 180 - 360° rotational segment of the fin spiral (i.e., the pitch of the spiral at different locations) can be the same or varied so as to provide similar or varied rates of heat transfer between the cooling medium and the coolant fluid along the axial dimension of the heat exchanger.

The coolant fluid inlet and outlet conduits 146 and 148 are connected to each other in a similar manner as described above and depicted in Fig. 2 to facilitate recycling and/or purification as well as selective forced flow (e.g., via pumps and/or fans disposed in-line with the recycling line) of the coolant fluid during system operation. Similarly, the inlet and outlet conduits 134 and 136 for the cooling medium may similarly be connected to each other to facilitate recycling and/or purification during system operation as described above.

During system operation, an optical fiber is directed between inlet 140 and outlet 142 and through the fiber channel of the inner tube section 124, while coolant fluid is directed through the inner tube section 124 (via inlet and outlet conduits 146 and 148) and cooling medium is directed through the annular gap 123 (via inlet and outlet conduits 134 and 136). The fins 126 provide effective mixing and enhanced heat transfer between the cooling medium and the coolant fluid to ensure the coolant fluid remains within a selected temperature range during system operation.

The heat exchanger embodiments of the present invention provide high cooling wall surface areas formed by the combination of fins and/or cooling enclosures disposed within the inner tube section. This in turn provides a substantial increase in contact area for heat transfer between the coolant gas flowing within the inner tube section and the surrounding cooling medium disposed within the outer tube section of the heat exchanger while minimizing the axial dimensions of the heat exchanger. Further, the amount of coolant fluid required to cool the fiber

at a selected rate within the heat exchanger is decreased in comparison to typical optical fiber heat exchangers due to the enhanced ability the system provides in controlling the temperature of the coolant fluid.

In addition, the arrangement of fins and/or cooling enclosures within the heat exchanger embodiments described above facilitates the use of a “clamshell” heat exchanger design (i.e., a heat exchanger that separates along its axial dimension into two or more hinged sections), which in turn facilitates easy opening and closing of the exchanger during periods in which the system is not being used.

Having described novel heat exchanger systems for cooling optical fibers, it is believed that other modifications, variations and changes will be suggested to those skilled in the art in view of the teachings set forth herein. It is therefore to be understood that all such variations, modifications and changes are believed to fall within the scope of the present invention as defined by the appended claims.